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New insights on Final Epigravettian funerary behavior at Arene Candide Cave (Western Liguria, Italy)

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Summary - *We gained new insights on Epigravettian funerary behavior at the Arene Candide cave through the osteological and spatial analysis of the burials and human bone accumulations found in the cave during past excavations. Archaeothanathological information on the human skeletal remains was recovered from diaries, field pictures and notes, and data from recent excavations was integrated. The secondary deposits have traditionally been interpreted as older burials that were disturbed to make space for new inhumations. Our results suggest that those disturbances were not casual: older burials were intentionally displaced to bury younger inhumations. Subsequently, some skeletal elements, especially crania, were arranged around the new burial; these were often placed within stone niches. Based on the composition of some clusters, which contain the bones of two individuals displaced together, it is possible that a double burial composed of two adults was originally present at the site. This would be a burial type that had not been recognized at Arene Candide until now. Strikingly, this potential double burial contained an individual showing pathological bowing of the limbs, a finding which is not infrequent in skeletons from Gravettian and Epigravettian multiple burials. In addition, the crania and other skeletal elements derived from this burial were intentionally placed around a new inhumation, whose skeleton possibly shows a milder form of the same disease (possibly hereditary rickets). This and other observations suggest that the five individuals belonging to the second phase of this “cemetery” (AMS dates spanning 12,030 – 11,180 cal BP) might have been buried over a relatively brief time span. Our study demonstrated similar behaviors in the first phase of mortuary use of the cave (12,820 – 12,420 cal BP), indicating a remarkable persistence in Final Epigravettian funerary models despite their archaeologically apparent rarity and intermittent nature.*

Keywords - *Mortuary program, Late Upper Paleolithic, Archaeothanatology.*

Introduction

Arene Candide is a large cave system accessed 90 m above current sea level on the slopes of Monte Caprazoppa, Finale Ligure, Italy (Fig. 1). Its name (White Sands) derives from a large white sand dune that rose from the sea up to the entrance of the cave, now quarried away. The site has been renowned since the latter half of the 19th century for the archaeological richness of its Holocene layers (Issel, 1864, 1908; Maggi 1997a,b; Rossi *et al.*, 2011), but it was only from the 1940s that its Pleistocene sequence came under investigation. Under the direction of Luigi Cardini and Luigi Bernabò Brea, several excavations occurred during 1940-42, 1948-50, and 1970-72. More recently, a series of excavation campaigns took place between 2008 and 2011 under the direction of J. Riel-Salvatore and R. Maggi. Thanks to the rigorous work of those earlier researchers, and to subsequent comprehensive multidisciplinary studies (Cardini, 1980; Bietti, 1994; Maggi, 1997a,b), Arene Candide now represents one of the most important sites for the understanding of the peopling of the Mediterranean in the Pleistocene and early Holocene.

During the 1940-1942 excavation, several Late Upper Paleolithic burials and secondary deposits of human bones were unearthed (see below). An additional burial was found in 1970, and, in 2011, a human bone (a talus) was found (Riel-Salvatore *et al.*, 2018). We aim here to gain new insights into Late Upper Paleolithic funerary behavior through the osteological and spatial analysis of those skeletal elements. The “Mesolithic necropolis”, as it became known (the cultural attribution is actually Final Epigravettian; Bietti, 1987, 1994; Bietti & Molari, 1994), was unearthed in the lower portion of a sequence of five layers constituting a 70-100 cm deep stratigraphy (Bietti & Molari, 1994; Rellini *et al.*, 2013). The deposit is chronologically bracketed between layers dating to 12,000 and 10,000 cal BP (Alassio *et al.*, 1966; Bietti, 1987; Bietti & Molari, 1994; Macphail *et al.*, 1994). Figure 2 places the necropolis in the cave and shows the relative position of the burials (modified

from Figure 2 in Cardini, 1980, p.12; see also Formicola *et al.*, 2005, Fig. 1); the position and orientation of the burial of an adolescent excavated in 1970-72 (Lamberti, 1971; Formicola & Toscani, 2014) has been added (Fig. 2b) based on field pictures and paint markers in the cave. In his site plan, Cardini identified the primary burials with Roman numerals (Fig. 2a), including clusters of bones that he recognized as disturbed burials. Based on this work, the “necropolis” comprises nine undisturbed primary burials (II, VA, VB, VII, VIII, IX, XI, XV, and AC 16), three disturbed but in part primary burials (VIA, VIB, and X), and five disturbed burials (I, III, XII, XIII, XIV). The disturbed burials would amount to six if we were to include cluster X, bones of which clearly derive from the primary inhumation X (Fig. 2a).

Cardini suggested that the individuals were in all probability buried at different times during the whole extent of cave's use by Final Epigravettian groups. However, he was unable to establish any specific chronological or detailed stratigraphic relationships between the burials (Cardini, 1980). More recently, Formicola *et al.* (2005) and Formicola & Toscani (2014) sampled bone from eleven individuals, and obtained AMS ¹⁴C dates on seven of these. Five (burials VIB, VIII, XII, XIV, and AC16) span the period 12,820 to 12,420 cal BP (10,585 ± 55 and 10,810 ± 65 BP; all dates calibrated at 2σ using OxCal 4.3.2, Bronk Ramsey (2017): Intcal13 atmospheric curve, Reimer *et al.*, 2013). These were therefore interred at least four centuries earlier than burials III and VB (10,065 ± 55 and 9,925 ± 50 BP respectively; 11,940 – 11,330 and 11,600 – 11,230 cal BP). Based on these direct dates, Formicola *et al.* (2005) suggested that funerary use of the cave occurred over at least two main phases: an early phase (henceforth referred to as “Phase I”), that coincided with the formation of layers 1-2 (Bietti & Molari, 1994); and a later phase (henceforth referred to as “Phase II”) at the end (i.e., layers 3-5) of the Final Epigravettian occupation of the site. Burial X-XI – although the study could not test the available date with a large error (GX-16960-A 11,605 ± 445 BP;



Fig. 1 – a) Geographic collocation of the Arene Candide cave in western Liguria, Italy; b) a view of the eastern portion of the cave, where the Epigravettian “necropolis” was unearthed; c) a plan of the cave, with indicated the area where the Pleistocene layers were reached and at least partially excavated. The small red square represents the area where excavations took place in 1974 and 1997–2002; those excavations did not yield human remains. The large red square encloses the areas where the excavations took place in 1940–42, 1948–50, 1970–72, and 2008–11; most burials were found during the 1940–42 campaigns, one during the 1970–72 excavations, and one human bone in 2011. The colour version of this figure is available at the JASs website.

14,970 – 12,700 cal BP) – appeared more compatible with Phase I, also considering the results obtained for cluster XII (GX-16964-K: 11,510 ± 385 BP; OxA-11002: 10,720 ± 55 BP respectively; 14,540 – 12,670 and 12,730 – 12,570 cal BP; Formicola *et al.*, 2005).

Formicola *et al.* (2005) also made inferences on the funerary behavior based on the dates and the relative position of the skeletal elements. Cardini suggested that all of the bone clusters resulted from disturbances caused by subsequent interments, and that only in a few cases (clusters

I and IV) did he “observe an intentional placement, almost a secondary deposition of groups of bones coming from previous disturbed inhumations” (translated from Cardini, 1980, p.13). Since the date obtained from cluster III belongs to the later phase, and no subsequent inhumations were placed nearby, Formicola *et al.* (2005) suggested that this cluster also constitutes a secondary deposition. The view that bone accumulations at Arene Candide are not the result of the need to make space for new inhumations, but signal secondary manipulation of burials, has

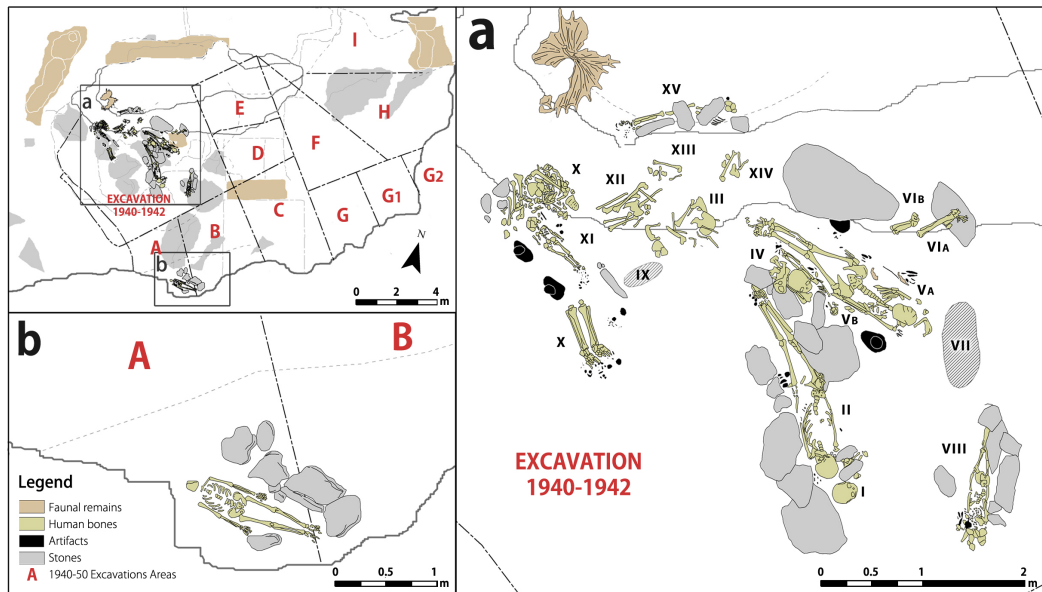


Fig. 2 – The Epigravettian necropolis in the eastern portion of the Arene Candide Cave: a) excavations 1940-42 and 1948-50, with the numbering of the burials and clusters of bones in secondary deposition attributed by Cardini (modified from Figure 1 in Cardini, 1980); b) the individual unearthed during excavations 1970-72 (modified from Formicola & Toscani, 2014) The colour version of this figure is available at the JASS website.

previously been proposed by Mussi (1989) and, as we will see, our results support her suggestion.

Formicola and co-workers (2005) furthermore noted that the interment of a Phase II double burial (burial VA-B) may have disturbed the skeletons of a Phase I double burial (burial VIA-B). Striking similarities in funerary behavior observable between the two phases include the fact that both double burials of each phase (VA-B and VIA-B) comprise an adult with a child lying to its left, and that the subsequent disturbance left in place only the lower limb bones, as in burial X-XI (Figure 2). Overall, it appears that the two phases of funerary use of the Arene Candide cave were modelled on similar mortuary patterns despite being separated by at least half a millennium (Formicola *et al.*, 2005). In the absence of a more detailed archaeological record, this suggests the cultural persistence of traditions of specific funerary activities (see below).

We build here upon these previous studies and conclusions, aiming to gain further insights

into funerary behavior and its persistence over time through the osteological analysis of the skeletal elements deriving from the accumulation of disturbed burials I, III, IV, XII, XIII, XIV and their relationships to the primary burials. These bone clusters are described as disturbed burials; for cluster III it is even suggested that bones were “retained in the depression which must have initially contained the body in articulation” (translated from Cardini, 1980, p.13). In the same monograph, however, Paoli *et al.* (1980) presented the first catalogue of the osteological material, and attribute these remains to an individual (Arene Candide 3) “on the basis of morphological and metric analogies, some bones in secondary deposition, which occupied a limited area indicated as Tomb III and Tomb IV” (translated from Paoli *et al.*, 1980, p.49). A similar conclusion was reached for the individual Arene Candide 4 (Paoli *et al.*, 1980, p.51), suggesting that bone clusters III and IV each actually contained skeletal elements of two individuals. In

addition, the bones from cluster I (a cranium and a right humerus) are attributed to an individual from cluster III (Arene Candide 3) by Formicola (1995), based on shared bowing deformities and abnormal tendon and ligament calcification (see also Formicola *et al.*, 1990). Cluster I laid close to the head area of the Arene Candide 2 burial, while cluster III was laid close to its feet. If the attribution of skeletal elements can be confirmed, cluster III would not be a secondary deposition made in the absence of any subsequent interment, but would be clearly associated with the interment of Arene Candide 2.

It therefore is necessary now to present a detailed and thorough assessment of which skeletal elements belong to which individual, and in which cluster of bone accumulations they were found. Only by doing so can we better recognize whether there was an “accidental”, if respectful, displacement of bones in order to make space for a new burial, a “reduction of the skeleton” in archaeological terms (Duday, 2006; Knüsel, 2014), or an intentional secondary manipulation of primary interments to deliberately associate their skeletal elements with a new inhumation.

Numerous prior anthropological studies have included data from the Arene Candide skeletal material (e.g. Parenti, 1947; Paoli *et al.*, 1980; Formicola, 1986a, 1987, 1995; Francalacci, 1989; Churchill, 1994; Holliday, 1995, 1999, 2002; Formicola & Franceschi, 1996; Holt, 1999, 2003; Churchill *et al.*, 2000; Holt *et al.*, 2000; Faerman *et al.*, 2006; Tarsi *et al.*, 2006; Formicola & Holt, 2007; Shackelford, 2007; Cowgill, 2008, 2010; Holt & Formicola, 2008; Villotte, 2008, 2009; Marchi *et al.*, 2006, 2011; Villotte *et al.*, 2010; Trinkaus & Ruff, 2012; Brewster *et al.*, 2014; Sparacello *et al.*, 2014, 2017; Villotte & Knüsel, 2014), or on single individuals from the necropolis (Formicola, 1986b, 1995; Formicola & Scarsini, 1987; Formicola *et al.*, 1990; Formicola & Toscani, 2014). However, the uncertainty about the attribution of elements from the secondary depositions often limited the sample size included in these studies, especially considering that access to the original publications in Italian may have

been an important obstacle in a number of studies. The only anthropological database following that of Paoli *et al.* (1980) in Italian was the recent database of skeletal material from Italian Paleolithic and Mesolithic sites (Alciati *et al.*, 2005). However, the publication did not attempt an attribution of the skeletal elements from the secondary depositions, effectively reducing the available sample size. Here, we revise the original attributions by Paoli *et al.* (1980) and provide the first complete anthropological database of the Arene Candide necropolis, including 3D surface models of all the skeletal material in the analysis. We hope that this work will contribute to our understanding of evolving funerary complexity at the end of the Pleistocene, as well as constitute a useful tool for researchers and a baseline for future targeted analyses of this unique assemblage from the Late Upper Paleolithic.

Materials and methods

The Arene Candide skeletal assemblage is curated in four Italian museums (Alciati *et al.*, 2005). The majority is housed at the Museo di Archeologia Ligure (Genova Pegli), which includes most of the primary burials as well as skeletal elements pertaining to the clusters of secondary burials. Two individuals from primary burials (Formicola, 1995; Formicola & Toscani, 2014) are curated at the Museo Archeologico del Finale (Finale Ligure). The cranium of one individual (Formicola & Scarsini, 1987) and partial remains of at least another four are curated in the Museo di Storia Naturale dell'Università di Firenze, Sezione di Antropologia e Etnologia (Florence). One human bone fragment possibly associated with the Gravettian “Principe” (Arene Candide 1), as well as some skeletal elements belonging to disturbed Epigravettian burials are curated at the Istituto Italiano di Paleontologia Umana in Rome (Alhaique & Molari, 2006).

In order to catalogue the entire assemblage, and to determine the minimum number of individuals, we directly examined all the skeletal material housed in Genova Pegli, Finale Ligure, and

Florence. We attributed a unique ID code to each bone found in a secondary deposit, based on the skeletal element, side, and the presence of markings made by Cardini during excavation (“painted dots” of various colors and numbers). We then assessed which elements might belong to the same individual based on direct articulation, measurements of the bone dimensions, estimated age at death, morphology, and in some cases color, preservation and cluster of provenience. The attributions based on articulation, size and morphology of the skeletal elements in secondary depositions were also verified through the analysis of 3D surface scans, as well as pictures. Surface scans were taken using the structured light scanner DAVID® SLS-2 (DAVID Group 2007-2015).

In addition to direct analysis, we collected all the available published and unpublished information on the spatial properties of the elements of the primary burials and of those in secondary deposits. We made use of unpublished information deriving from the transcription of the excavation diaries of Luigi Cardini and field pictures (Campaign II: April 25 – June 4, 1941; Campaign III: November 17 – December 13, 1941; Campaign IV: March 20 – May 22, 1942; archives of the Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Genova e le province di Imperia, La Spezia e Savona) and from Cardini’s hand-written notes associated with the skeletal material in the museums of Genova Pegli and Florence. These notes list the skeletal elements from clusters I, III, IV, XII, XIII, XIV, and indicate from which specific cluster they derive. We also cross-referenced numerous published sources containing partial lists of burials and skeletal elements in secondary deposits (Cardini, 1980; Paoli *et al.*, 1980; Alciati *et al.*, 2005; Alhaique & Molari, 2006; Moggi-Cecchi, 2014) and incorporated revisions by Formicola (1995) and Villotte (2009, and personal communication).

We also used numerous published sources: the main monograph on the Arene Candide necropolis was published in 1980, and the chapters by Cardini (1980) on the burial composition and by Paoli *et al.* (1980) on skeletal measurements and

morphology formed the basis for this study. Earlier publications by Cardini were also consulted (e.g., Cardini, 1942, 1946), as were partial publications of the original excavation diaries (Cilli *et al.*, 2000). Notes on the composition of the few skeletal elements preserved in Florence (Museo di Storia Naturale dell’Università di Firenze, Sezione di Antropologia e Etnologia) and Rome (Istituto Italiano di Paleontologia Umana) are presented in Moggi Cecchi (2014) and Alhaique & Molari (2006). The recent catalogue of the Italian fossil human remains from the Paleolithic to the Mesolithic (Alciati *et al.*, 2005) was also consulted. However, Paoli *et al.* (1980) work formed the starting point for the attribution of skeletal elements to an individual, although revisions of their attributions, especially regarding the individual catalogued here as Arene Candide 3, had been made already by Formicola (1995) and Villotte (2008, 2009, and personal communications).

Skeletal measurements were transcribed from Paoli *et al.* (1980) for most of the Epigravettian skeletal material (excavations 1940-42 and 48-50), and from subsequent studies on the material which was excavated between 1970 and 72, or was not included in the original monograph (Messeri, 1980; Formicola & Scarsini, 1987; Scarsini, 1987; Formicola & Toscani, 2014). Measurements taken for other anthropological studies were included when they did not overlap with previous data (Parenti, 1947; Paoli, 1976; Pearson, 1997; Sparacello *et al.*, 2014), and new measurements were taken on the talus (AC 29) discovered in 2011 (Riel-Salvatore *et al.*, in press). For the Gravettian “Principe”, data from Sergi *et al.* (1974), Paoli (1974), and Pearson (1997) were included.

Results

Note on the raw data and Supplementary Information

The work of revising the anthropological remains and the archaeobotany of the Epigravettian of Arene Candide Cave employed, produced and/or organized a large amount of raw data (excavation diaries, field pictures,

measurements, 3D surface scans). In addition, some of the skeletal attributions or archaeothanatological deliberations are based on the cross-referencing of different sources, and result in lengthy and detailed considerations. In order to improve the legibility of the paper, and to adhere to the editorial limits of the journal, we report here the results of the analysis in a condensed form. However, our intention was to make as much as possible of the raw data available to the scientific community, and to provide all the elements for an independent verification of our conclusions. We therefore included as Supplementary Information of this paper several resources listed below.

- 1) S1_Database: this folder includes the complete database of the skeletal elements in secondary deposit, the attribution of each bone ID to an individual and to a cluster, a picture of each element, and a list of the weblink where the 3D surface scan can be downloaded (obj files with textures, and stl files) from the website www.morphosource.org under "The Arene Candide 3D Database".
- 2) S2_Osteometrics: a table containing all the available osteometric measurements for the Upper Palaeolithic skeletal series of Arene Candide.
- 3) S3_Details on secondary depositions: contains a more detailed report on how the archaeothanatological result were obtained, including a map listing each bone ID for each cluster, and some key field pictures. This Supplementary Information enriches the evidence provided in Section 3.3 below.
- 4) S4_Detailed Tables: two tables further detailing the information available in Table 1, including the osteological composition of each catalogue entry.

In order to avoid breaking the flow of this manuscript, we avoided to continuously referencing the Supplementary Information for further details and justification of the results presented below. However, they are fundamental tools for the reader that intends to verify our results and conclusions.

Database composition

Appendix presents a new labeling of the Arene Candide Paleolithic skeletal series that is distinct from that used in earlier catalogues and publications. We included the available AMS ^{14}C dates, and the estimates of age at death and sex of the individual (mostly based on previous studies, e.g. Paoli *et al.*, 1980; Cowgill, 2008; Villotte, 2008, 2009). We attempted to construct a numbering that was consistent with earlier denominations, but also incorporated some changes proposed in the catalogue of Italian Paleolithic burials (Alciati *et al.*, 2005). In particular, the cranium of the first cluster "Tomba I" now belongs to "Arene Candide 3", and the label "Arene Candide 1" is reserved for the Gravettian "Principe". As in Alciati *et al.* (2005), the entry "Arene Candide 12" includes the cranium previously identified as number 19 (Formicola & Scarsini, 1987).

Figure 3 shows the numbering and position of the catalogue entries corresponding to primary burials in the plan of the Epigravettian necropolis, based on the figures of Cardini (1980) and Formicola *et al.* (2005), with the addition of the burial AC 16 (drawing from Formicola & Toscani, 2014). Figure 4 shows the numbering and position of the catalogue entries corresponding to secondary clusters of skeletal elements.

The catalogue includes 31 entries, which consist of complete burials, isolated bone elements, and groups of elements that most likely belong to the same individual. One entry, "AC 3 or 4", includes skeletal elements that could belong to one of those two individuals. In some cases, we cannot exclude the possibility that different entries might belong to the same individual. Therefore, the minimum number of individuals, obtained by considering the attributions in S1, is 20. The minimum number of individuals calculated using a simpler approach would be 18, i.e. by considering primary burials and the number, laterality, and ontogenetic phase of the humeri in secondary deposition ($n = 9$).

Primary burials (and disturbed primary burials) consist of 12 individuals (AC 2, 5, 6, 7, 8, 9, 10, 11, 15, 16, 19, and 20), two of which (7 and 9) were fetal or perinatal individuals whose

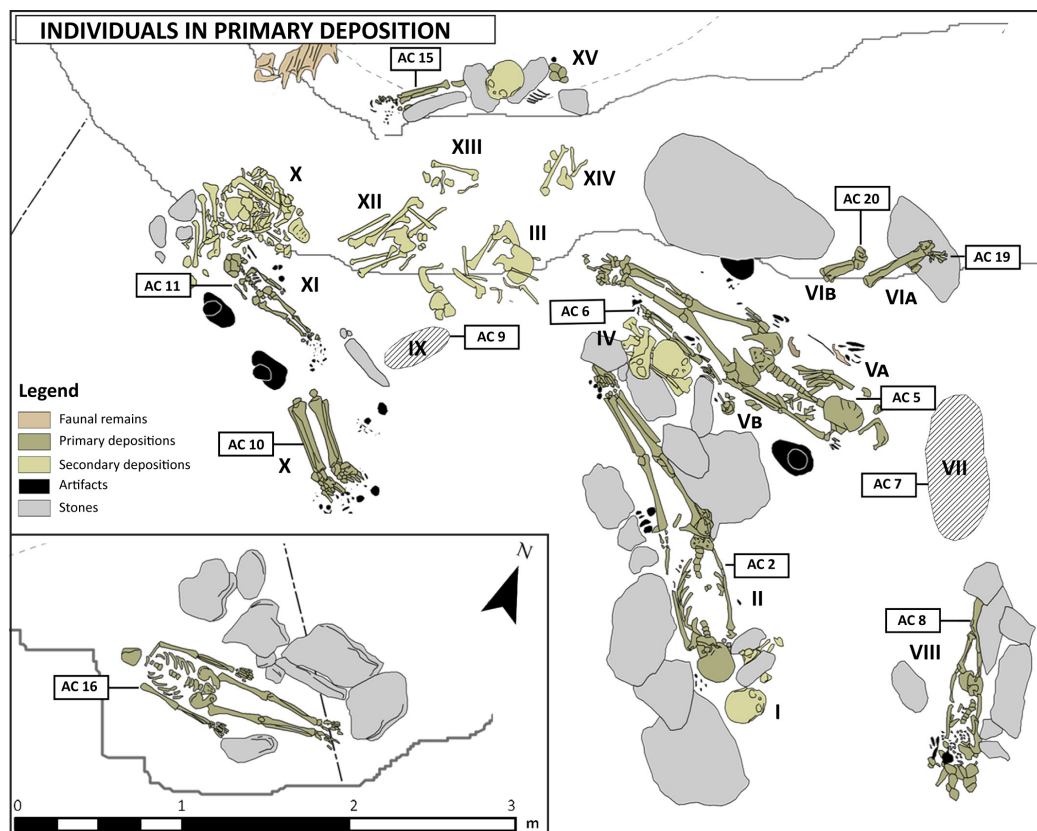


Fig. 3 – The spatial collocation and catalogue numbering attributed in this paper of the individuals in primary deposition at Arene Candide Cave. Roman numerals indicate the burials and clusters of bones in secondary deposition attributed by Cardini. The colour version of this figure is available at the JASs website.

remains were not retrievable (Paoli *et al.*, 1980; Alciati *et al.*, 2005). Secondary depositions comprise the partial skeletons of 5 individuals (AC 3, 4, 12, 13, 14). In addition, one ulna (AC 23) does not articulate with any humerus, suggesting the presence of an additional individual. Remains from two additional juvenile individuals (AC 24 and 30) do not seem to match with any other burial or partial inhumation.

The rest of the entries may belong to individuals that have already been counted. Plausible associations, based on morphology, size, and color, can be made in the case of the catalogue entry AC 29 with the partial individual AC 13 (the talus articulates with the corresponding calcaneus,

see 3D reconstruction and virtual articulation at the weblink <https://doi.org/10.17602/M2/M10765> http://www.morphosource.org/Detail/MediaDetail/Show/media_id/8544), or AC 14 and 25. The young adult fragmentary remains AC 21 and 22 may belong to the young adult AC 19, which is a disturbed burial close by. The remains catalogued as AC 17, 18, 31 (cranial fragments and mandibula) and AC 26 (both ossa coxae) may belong to any individual missing those elements (AC 13, 14, 19, 23). The phalanx catalogued as AC 27 was found in the AC 5 burial (according to the note associated with the skeletal element), but possibly belongs to cluster IV, and therefore to AC 3 or 4 (Appendix).

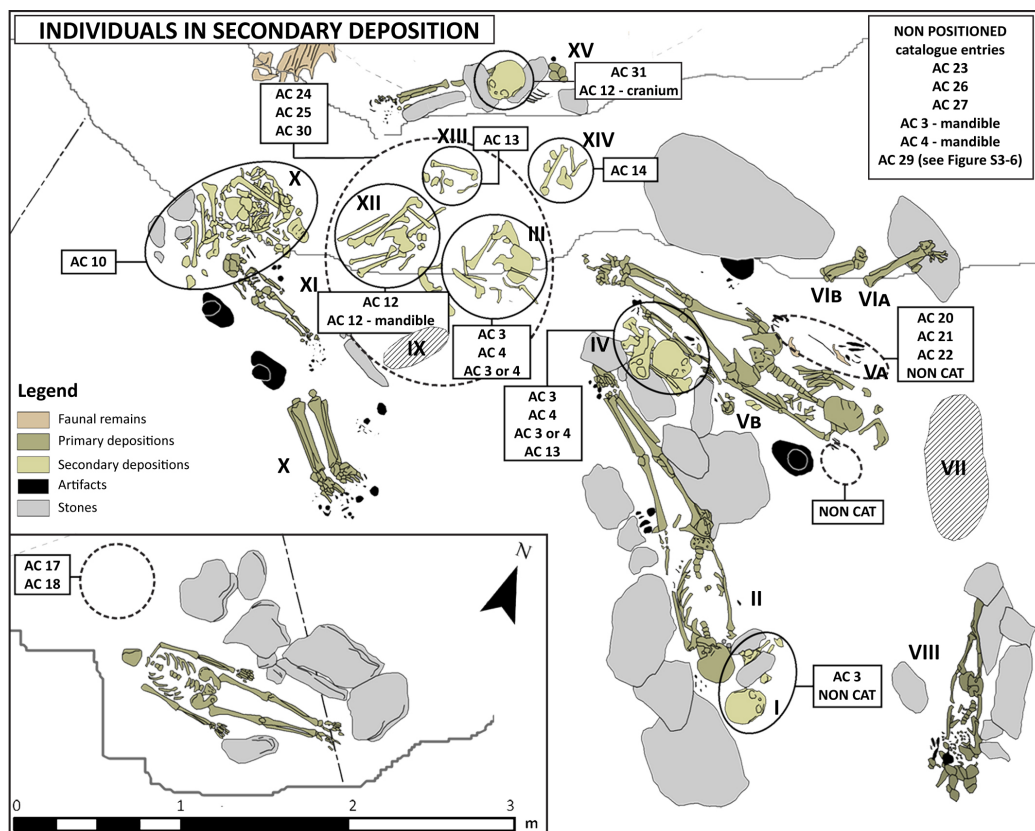


Fig. 4 – The spatial collocation and catalogue numbering attributed in this paper of the individuals in secondary deposition at Arene Candide Cave. Roman numerals indicate the burials and clusters of bones in secondary deposition attributed by Cardini. The colour version of this figure is available at the JASs website.

In addition to the Epigravettian “necropolis”, the database contains an entry for the Gravettian “Principe” (AC 1) and for the other human bone found in its Gravettian layers (AC 28), an acetabular fragment of a juvenile right os coxae. According to Alhaique and Molari (2006), a note accompanying this bone fragment attributes it to the feet area of AC 1.

Spatial distribution of skeletal elements in secondary deposition

Clusters III, XII, XIII, and XIV. The main cluster of disarticulated skeletal elements (about 130), which is the focus of this study, lay west of the feet of burials AC 5-6 and AC2, and was

delimited by the burials of AC 15 in the north, and AC 10-11 in the south (Figs. 3 and 4). It was subdivided into four sub-clusters by Cardini (1980): III, XII, XIII, and XIV (Fig. 2). Our analysis suggests that three clusters each contain mainly the bones of a single individual (XII: AC 12; XIII: AC 13; XIV: AC 14), and one contains the remains of two individuals (III: AC 3 and AC 4). The eight skeletal elements catalogued as AC 23, 24, 25, and 30 were found in the larger main cluster, but could not be attributed with certainty to any sub-cluster (Fig. 4).

Clusters I and IV. The other two clusters of skeletal elements in secondary deposits that could be documented in detail are in strict

relationship with burial AC 2 (Fig. 3): cluster IV lay to the north of the feet of this burial, and cluster I was close to its head (Fig. 4). We were able to assess that cluster IV contained the bones of three individuals: the vast majority of these belonged to AC 3 and AC 4, including the cranium of AC 4. However, as already noted by Paoli *et al.* (1980), two tarsal bones from this cluster articulate with elements from AC 13 (Fig. 4). Cluster I consists of the cranium of AC 3 and skeletal elements of the same individual. A few additional skeletal elements belonging to this cluster were noted in the excavation diaries, but could not be found in any of the museums (the presence of skeletal elements that were not catalogued and could not be retrieved is indicated with the acronym “NONCAT” in Figure 4).

Elements associated to burial VA-VB. It appears that also the burial VA-VB (AC 5 and 6) had associated clusters of skeletal elements in secondary deposits. We catalogued those skeletal elements as AC 19, 20 (the catalogue entries also include the corresponding portions found in primary deposition, Figures 3 and 4), 21, 22 (which might belong to AC 20 as well, but this could not be verified). The existence and collocation of those skeletal elements is based on the details provided in the excavation diaries and pictures, but they could not be catalogued and analyzed in detail because they were not rigorously listed, and in some cases could not be retrieved (“NONCAT” in Figure 4). It is interesting to notice, however, that the diaries report elements that appear “clearly stacked” next to the right shoulder of AC 5. The cranial fragments and maxilla catalogued as AC 21 were “embedded in the same mass of ochre that covers all the burial” (from the diaries of the 1940-41 campaigns). Some cranial fragments cover, while others are covered by, the grave goods of AC 5 suggesting that these skeletal elements were intentionally included in the burial. The rest of the skeletal fragments seem to have been either transferred above the burial with its covering soil, or were surfacing from the ground when the double burial AC 5-6 was emplaced.

Elements that could not be positioned. Other skeletal elements that could not be positioned accurately (Fig. 4) include: 1) two ossa coxae belonging to the same individual (AC 26) which, according to a field picture may have been found north of burial VA-VB together with other skeletal elements which could not be retrieved; 2) a hand phalanx (AC 27) which was probably found in the area of AC 5; 3) a rib fragment from cluster I, III, or IV; 3) the mandibles of AC 3 and AC 4; 4) the ulna AC 23. Finally, the fragment of frontal bone AC 17 and the mandible AC 18 were unearthed in the “Zona A” during the 1970 excavation, close to burial AC 16 (Fig. 2), but a more precise spatial collocation is not possible.

Discussion

We make here new inferences on the funerary behavior of Final Epigravettian people at Arene Candide through the complete cataloguing and spatial analysis of the clusters of bones in secondary deposits, and from analyzing the relationship of these clusters to primary burials. Cardini’s excavations were rigorous for their time, and although the concept of taphonomy and archaeoethanatology (Duday, 2009) had not yet developed, the excavation diaries contain valuable notes on the distribution and deposition of these “disturbed burials”. An extensive work of cross-referencing between bone morphology, excavation diaries, pictures, and previous attribution (Cardini, 1980; Paoli *et al.*, 1980) still had to be performed to make the Arene Candide assemblage fully available to the scientific community. The anthropological database presented here is the first step in this process and, while it confirms most of the excellent work undertaken in those earlier studies and incorporates some recent revisions (Formicola, 1995; Villotte, 2008, 2009), it also enables some significant advances to be made in interpretations.

The minor mismatches between the attributions proposed in this paper and those previously established (Paoli *et al.*, 1980) are detailed in S1. The attribution of some additional skeletal

elements to individuals already recognized (e.g. phalanges added to AC 12, a juvenile metacarpal added to AC 13, or the juvenile ribs to AC 24; number 16 in Paoli *et al.*, 1980), or the changing of some elements from one individual to another (e.g. most of the cervical and thoracic vertebrae from cluster III were attributed to AC 3, while here they are attributed to AC 4) can be verified by analyzing the 3D models as well as the evidence provided in S1 and S3 and, we believe, do not require a detailed discussion in this section. The same is true for the creation of additional database entries for skeletal elements that had been overlooked in previous studies (e.g. AC 25, 26, and 30).

One major difference between this study and previous analyses concerns the demographic composition of the adults buried in the necropolis (Tab. 1). There is no evidence based on pelvic or cranial morphology that any of the individuals buried in primary or secondary deposits are female. The pair of ossa coxae that could not be positioned or assigned to any individual (AC 26) are male. The individuals recognized as females in Paoli *et al.* (1980) are, in fact, either male or of undetermined sex. More specifically, Paoli *et al.* (1980) attributed the ossa coxae of AC 3 to a female, but subsequent analyses suggested a male determination (Villotte, 2008, 2009). Moreover, Paoli *et al.*'s work was probably influenced by the perceived gracility of the left humerus attributed to this individual. However, he attributed the cranium and a robust right humerus found in cluster I to a male (Paoli *et al.*, 1980, pp. 39–43). We demonstrated here that those elements belonged to AC 3 as well, therefore the sex of this individual is male. The same bias towards attributing gracile skeletal elements to females can be noted for AC 13 and 14: no associated os coxae or cranium was available for those individuals, and their sex is therefore indeterminable. Even if we assume that sexual dimorphism in diaphyseal robusticity (*sensu lato*) was high during the Late Upper Paleolithic (Sládek *et al.*, 2016; but see Churchill *et al.*, 2000), AC 13 is a late adolescent while the humerus of AC 14 is from the left side. Marked gracility in left humeri is seen in virtually

all Upper Paleolithic individuals, including those from Arene Candide (Sparacello *et al.*, 2017; see the 3D scans, including those of AC 5 and AC 10 humeri; note that AC 10 was probably left handed). Therefore, the attribution of those skeletal elements to female individuals does not appear justified. Inferences based on differing funerary treatments of males and females in the Final Epigravettian of Arene Candide should, we suggest, be revised based on the absence of evidence for female burials in the excavated area of the cave (e.g., Mussi, 2001, p. 348).

Another major difference between the attributions made by Paoli *et al.* (1980) and those proposed here has an important bearing on our understanding of funerary practices, in particular for Phase II interments. Osteological analysis confirms that the skeletal elements from cluster I belong to AC 3, as already implied in previous studies (Formicola, 1995). We were also able to confirm that clusters III and IV contained the bones of two individuals: AC 3 and AC 4 (almost exclusively, see discussion about AC 13 below). Both clusters I and IV contained a cranium (I from AC 3; IV from AC 4) and were closely associated with a more recent deposition, AC 2. As noted by Cardini (1980), these were most likely intentional secondary manipulations: the bones of AC 3 and 4 were clearly stacked in cluster IV, protected by the stone slabs arranged around AC 2, and the cranium was placed above the stack (details and pictures in S3). In cluster I, the cranium of AC 3 was almost touching the cranium of AC 2 (details and pictures in S3). Cluster III was less than a meter west of the feet of AC 2 and contained the remaining skeletal elements of AC 3 and 4. Cardini interpreted this last cluster as a disturbed burial that, although no longer in anatomical connection, was still located in the original burial pit (Cardini, 1980). Cardini, however, most likely did not know that cluster III contained the same individual as I and IV: the 1980 monograph, which includes the work of Paoli *et al.* (1980), is posthumous. Subsequent studies considered that cluster III (together with XII, XIII, and XIV) was located in a part of the cave that revealed no evidence of subsequent

interments and therefore it was considered a secondary burial (Mussi *et al.*, 1989; Formicola *et al.*, 2005).

Based on the evidence presented here it can be hypothesized that AC 3 and AC 4 were originally buried together as a double burial, which was subsequently re-arranged in order to facilitate the interment of Arene Candide 2, and most likely to put the newly interred in close spatial association with the bones of AC 3 and AC 4. This was possibly done on the basis of shared congenital pathological conditions and/or relatedness between individuals involved in the creation of this funerary treatment context. In fact, both AC 2 and AC 3 show skeletal traits suggesting a congenital form of rickets (Formicola, 1995; see discussion below).

The original position of the presumed double burial is impossible to determine, but could have been in the center of the excavated area of the necropolis, where AC 2 was subsequently interred. We suggest that the bones of AC 3 and 4 were initially moved aside, towards clusters XII–XIV (belonging to Phase I of the necropolis, Formicola *et al.*, 2005), in order to make space for the new inhumation, in a fashion similar to that observed in burial X–XI. This action resulted in the mixing of the skeletal elements of the two individuals AC 3 and 4 in the newly formed cluster III which, according to Cardini (1980), was found slightly higher than the more recent AC 2. The fact that bones of AC 3 and AC 4 were completely mixed in cluster III suggests that the displacement of the two skeletons was performed in a single action, and that therefore the two individuals were either very close to one another or even interred together in a double burial. Subsequently, a number of skeletal elements, including the crania of AC 3 and 4, were removed from cluster III and arranged around AC 2, forming clusters I and IV. During this stage of the mortuary activity, two tarsal bones that were most likely part of cluster XIII (they perfectly articulate with elements belonging to AC 13) were moved, we think unintentionally, to cluster IV. The presence of skeletal elements from cluster XIII in cluster IV supports the

reconstruction of two stages of movement (moving aside bones, and then selecting elements to place around the new inhumation) during the funerary rite: if the bones of AC 3 and 4 had been moved in three different directions to make space for AC 2, the skeletal elements belonging to AC 13 would have not ended in cluster IV. In addition, this suggests that the bones in cluster XIII, and probably the ones in clusters XII and XIV, lay on (or close to) the surface at the time of the burial of AC 2 (as suggested previously by Henry-Gambier, 2001: 132).

Unfortunately, AC 13 has not yet been directly dated, but two considerations suggest that it belongs to Phase I. First, as with AC 12 and AC 14 (dated to Phase I, Table 2), the bones of AC 13 were found at the margins of the large scatter of skeletal elements initially referred to as “Tomba 3” by Cardini (which then was divided into clusters III, XII, XIII, XIV). Second, as with AC 14, AC 13 comprises only a few skeletal elements. Dating AC 13 would contribute to determining whether or not the secondary depositions at Arene Candide had remained close to the surface for several centuries.

Another result of our work related to AC 13 is the intriguing finding that one skeletal element (AC 29) found in 2011 about 8 meters east of cluster XIII (Fig. S3–7) and thus well outside of the known perimeter of the Epigravettian necropolis, very likely belongs to individual AC 13. The bone is a left talus that perfectly articulates with the left calcaneus of AC 13 from cluster XIII, and could be contralateral of the right talus (the articulated tali and calcanei 3D file is available at the weblink <https://doi.org/10.17602/M2/M10765> http://www.morphosource.org/Detail/MediaDetail/Show/media_id/8544). Micromorphological studies of the M1–M2 levels provide evidence of an in-situ occupational floor without significant post-depositional disturbances (Macphail *et al.*, 1994). Given that skeletal elements belonging to AC 13 had already been displaced during the formation of cluster IV (see above), the position of this talus so far from the necropolis proper may be due to other as yet undefined mortuary activities at the site (e.g., Gravel-Miguel *et al.* 2017;

Riel-Salvatore *et al.*, 2018), and may hint at the presence of additional burials in the unexplored Epigravettian deposits in the eastern part of the cave, next to the area explored during the 2008–2011 excavations.

Based on our considerations on the funerary processes that led to the arrangement of AC 3 and 4 around AC 2, we can hypothesize that individuals put in connection by means of the funerary rite belonged to the same phase of use of the necropolis (Phase I: 12,820 – 12,420 cal BP; Phase II 12,030 – 11,180 cal BP; Formicola *et al.*, 2005). If this is true, we could extend the AMS ^{14}C date for AC 3 (10,065±55 BP; 11,940 – 11,330 cal BP) to AC 4, which has not been directly dated (Formicola *et al.*, 2005). In addition, we can extrapolate a date for AC 2, which, based on results published to date (Formicola *et al.*, 2005) failed to yield sufficient collagen for AMS ^{14}C dating. The excavation diaries clearly state that cluster IV lay above another undisturbed double burial (AC 5–6; Cardini, 1980; see also pictures in S3) which was dated to 11,600 – 11,230 cal BP (9,925±50 BP; Formicola *et al.*, 2005). Given that the formation of clusters I and IV is contemporary with the deposition of AC 2, this date provides a *terminus post quem* for the burial. Regarding a *terminus ante quem*, the top of layer 1 of the Epigravettian sequence is dated to 12,030 – 11,180 cal BP (9,980±140 BP; Bietti *et al.*, 1994). Based on the above evidence, we propose that Arene Candide 2, 3, 4, 5, and 6 are roughly contemporaneous to one another, dating to somewhere between 12,030–11,180 cal BP, based on the radiocarbon age ranges for Phase II of the Epigravettian occupation of the cave (Fig. 5).

Another burial that could not be dated in previous attempts due to lack of preserved collagen (Formicola *et al.*, 2005; Tab. 2) is burial XV (AC 15), named “Burial of the Antlers” due to the nearby deposition of moose antlers. In this study (Supplementary Material S3), we confirmed that the cranium of AC 12 was found above burial XV (e.g., Formicola & Scarsini, 1987). Indeed, it was deposited in a stone niche formed by the slabs covering burial XV. Postcranial remains of

AC 12 have been dated to 12,730– 12,570 cal BP (10,720±55 BP), and lay in cluster XII, in the same general area of cluster III (Figure 2). This suggests a similar behavior to that seen in AC 2, 3, 4, i.e. the initial displacement of a burial and the subsequent selection of skeletal elements from it – particularly crania – to link to the new burial. If AC 12 cranium was deposited intentionally above burial XV, as it seems, the date of this individual does not constitute the *terminus ante quem* for the deposition. However, if individuals put in connection by means of the funerary rite did belong to the same phase, burial XV would belong to the Phase I of the necropolis. It should be noted that this extension of the dates based on funerary relationships is rather speculative, and that new direct dates would be integral to our understanding of the funerary processes at this site.

Interestingly, cranial elements (AC 17 and 18) – as well as moose antlers – were found also in the “Zona A”, close to the burial of AC 16. However, the lack of documentation makes their association with the burial tentative at best. Nevertheless, the similarities in funerary behavior between the two phases of funerary activity at the site, which appear separated by at least four centuries, appear even more striking than previously recognized (Cardini, 1980; Formicola *et al.*, 2005).

At this stage of research, we would suggest that there is evidence – in both phases – of intentional disturbance and repositioning of skeletal elements to link burials belonging to the same phase, i.e. AC 12 and 15 for Phase I, and AC 2, 3, and 4 for Phase II. Unfortunately, due to lack of clear documentation, it was not possible to determine whether AC 19–20 (Phase I) was rearranged for the interment of AC 5–6 (Phase II), or whether AC 19–20 had been displaced during another funerary intervention of Phase I, of which further traces have been lost.

Nevertheless, our new analysis provides evidence of a remarkably long persistence of Upper Paleolithic cultural traditions in the funerary realm, and additionally suggests that burial activity specifically at Arene Candide occurred within relatively brief periods of time, probably separated by several centuries. This persistence

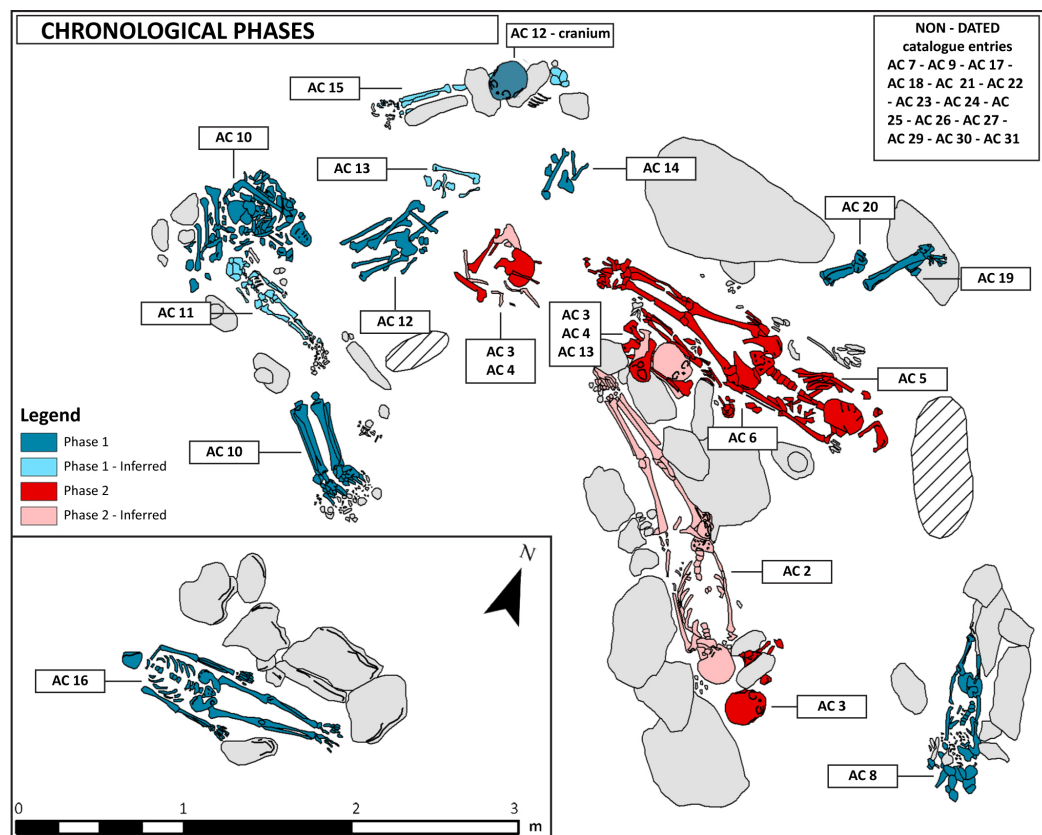


Fig. 5 – A color representation of the chronological phases of funerary use of the Arene Candide Cave. Phase I (blue): AMS dates spanning 12,816 – 12,421 cal BP at 2 σ ; Phase II (red): AMS dates spanning 12,028 – 11,181 cal BP at 2 σ . The individuals with a lighter tone of the two colors representing the phases are the ones for which there is no published direct date, but an attribution to a phase can be proposed (see main text). The colour version of this figure is available at the JASS website.

reflects an extreme degree of conservatism in social norms that may be related to behavioral strategies such as intentional place-marking (Riel-Salvatore and Gravel-Miguel 2013: 335–336) developed by foragers as a way to cope with the unpredictable conditions of the Younger Dryas. The excavation of the remaining Final Epigravettian deposits in the cave, as well as of other caves in the Finalese area that contain Late Upper Paleolithic horizons should in time help test these ideas and observations.

It is interesting to note how a similar mix of primary and secondary burials, as well as the removal and re-deposition of crania in

association with later interments at a number of Epipalaeolithic (Iberomaurusian) sites in Morocco and Algeria (Mariotti *et al.*, 2009, 2014). This may suggest that the remarkable persistence of the funerary behavior observed at Arene Candide did not extend only in time, but also in space over vast areas of the Late Upper Paleolithic Mediterranean littoral. Furthermore, similarities in the mortuary program can be also pointed out with Mesolithic cemeteries elsewhere in Europe (e.g. Stutz *et al.*, 2013), however a detailed review of these similarities and their implications goes beyond the scope of this paper and will be tackled in future studies.

Palaeopathological considerations related to funerary behavior

We demonstrated a strong funerary association between AC 2, 3, and 4 exemplified by the arrangement of clusters I and IV. Palaeopathological data further support the idea that the displacement of AC 3 was not casual: this individual displays short stature, bowing of limbs and abnormal enthesal changes, including a disproportionate mental spine, which are suggestive of hereditary X-linked hypophosphatemic rickets (Formicola, 1995). Likewise, the skeleton of AC 2 shows signs of rickets such as frontal bossing, enlargement of the metaphyses, and long bone curvature (Formicola, 1995), as well as the absence of the lesser trochanter of both femora (Formicola *et al.*, 1990; see also 3D surface scans of AC 2 at morphosource). While a traumatic origin of this last trait is possible, it might be better explained in a context of disturbances in bone and cartilage ossification, possibly due to the same X-linked hypophosphatemic rickets syndrome (Formicola, 1995). Although the diagnosis is tentative (especially for AC 2) in the absence of a genetic test, the presence of such a rare congenital condition in two individuals would suggest a shared maternal lineage. The re-arrangement of the older AC 3 cranium close to the skull of AC 2 may therefore be a sign of relatedness, which may have been recognized by the people who buried both individuals. If this is true, at least three (AC 2, 3, and 4) of the five individuals (including also AC 5 and 6) buried in Phase II of the necropolis could well have been buried, possibly by the same group, during a time span perhaps as limited as one or two generations.

Double burials comprising two adults are as yet unknown at Arene Candide: known double burials are only comprised of an adult and a child (AC 5-6, AC 19-20). It should be noted that, if indeed AC 3 and 4 were in a double burial, it would be another case of an Upper Palaeolithic (Gravettian or Epigravettian) multiple burial containing a pathological individual, and in particular an individual with skeletal dysplasias (Formicola, 2007). Similar cases are present in the double burial from Romito, containing

an acromesomelic dwarf (Mallegni & Fabbri, 1995), the double burial of Sunghir, and the triple from Dolní Věstonice, containing an individual with severe bowing of limbs and other dysplasias (Trinkaus *et al.*, 2001, 2014; Formicola & Buzhilova, 2004; Trinkaus & Svoboda, 2006; Cowgill *et al.*, 2012), the triple burial from Barma Grande, where the adult shows abnormal upper limb asymmetry (Churchill & Formicola, 1997), and the double child burial from Grotta dei Fanciulli/Grotte des Enfants, where one individual, in addition to a projectile weapon injury, shows indicators of vitamin D deficiency (Henry-Gambier *et al.*, 2001). Congenital and developmental anomalies, as well as perimortem trauma, have also been reported in other Upper Palaeolithic funerary contexts, such as single burials (e.g. Sergi *et al.*, 1974; Villotte *et al.*, 2011, 2015; Trinkaus *et al.*, 2015; Wu *et al.*, 2013).

Based on the above evidence, it has been suggested that Upper Paleolithic burials represented a ritual to “contain” and ritualize “bad deaths” or pathological conditions (Pettitt, 2012; see also Formicola, 2007). In this scenario, low genetic diversity and X-linked hereditary diseases (diagnosed for AC 3, and possible for AC 2, see above) might at least partially explain the sex bias observed in the skeletal assemblage. In fact, recessive X-linked mutations are expressed with much higher frequencies in males (Dobyns *et al.*, 2004): if the frequency of a particular mutation was f in males (e.g. 1%), women would have a frequency of f^2 ($1\% \times 1\% = 0.01\%$). It is well known that sex chromosomes are more likely than autosomes to be affected by drift, bottlenecks, and low population sizes (Whitlock & Wade, 1995); all phenomena that were most likely shaping the genetic makeup of European periglacial hunters. The sex bias in the burial assemblage would therefore be a by-product of higher male susceptibility to X-linked congenital disease due to inbreeding: males would have been disproportionately subject to those “bad deaths” for which formal burial was performed by Upper Paleolithic people. Moreover, if rare mutations leading to X-linked hypophosphatemic rickets were present at Arene Candide, it is plausible that other more common X-linked diseases,

which leave no clear traces on the skeleton, such as haemophilia, were an even greater problem for Late Upper Paleolithic groups. These considerations are at the moment speculative, and do not take into account the possibility of female-specific congenital diseases (e.g. Reijnders *et al.*, 2016); future aDNA analyses of the skeletal series from Arene Candide might investigate this hypothesis and shed light on the selective nature of Late Upper Paleolithic funerary practices. This would allow the field to move away from simplistic discussions about emergent sex-based social status in the Paleolithic that have tended to dominate analyses of sex ratios in Upper Paleolithic burials so far (cf. Riel-Salvatore & Gravel-Miguel, 2013).

Conclusions

Through the cataloguing, attribution, and spatial positioning of the bones in secondary deposition, this study sheds new light on Final Epigravettian funerary behavior at Arene Candide, and it allows for a better understanding of the tempo and mode of the depositional processes leading to the creation of the “necropolis”. As noted in previous studies, the “necropolis” accumulated in two phases, separated by a *hiatus* of a few centuries. It appears clear that the two phases of funerary use of the cave were modeled after similar burial practices. Bones were not simply put aside to make space for a new burial but, after initial removal into a cluster, some elements (particularly the crania) were selected and carefully re-arranged around the new inhumation. We presented evidence supporting this behavior in both phases; moreover, based on the available dates and on pathological similarities between AC 2 and AC 3, we suggest that the individuals from Phase II might have been buried, perhaps by the same group, over a relatively short period of time. Our analysis provides evidence of a remarkably long persistence of Upper Palaeolithic cultural traditions in the funerary realm, despite the (actual or perceived) rare and discontinuous nature of mortuary behavior at the time. Our study provides a new impulse for

the excavation of the Final Epigravettian layers in the cave, as well as for the exploration other caves in the Finalese area to determine whether this observation of rarity and discontinuity is real or the result of bias due to insufficient data.

Overall, the re-assessment and cataloguing of the Arene Candide skeletal series, as well as the careful analysis and cross-referencing of excavation diaries, notes, and field photographs, provides a number of insights that improve our understanding of Final Epigravettian funerary behavior at the site. We believe that this work provides the basis for future targeted analyses on the skeletal assemblage, and we hope it will stimulate renewed investigations in the Pleistocene deposits at Arene Candide and nearby sites. Finally, the database associated to this study, and the 3D surface scans made available in the website www.morphosource.org, constitute an important open-access tool for future morphological and morphometric studies by the whole scientific community.

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Tab. 1 – List of individual entries for the Arene Candide catalogue of skeletal elements. AMS dates, when available, derived from: a, Pettitt et al., 2003; b, Formicola at al., 2005; c, Macphail et al., 1994; d, Formicola & Toscani, 2014.

THIS CATALOGUE	HUMAN REMAINS FROM CARDINI (1980) BURIALS ATTRIBUTED TO THE CATALOGUE ENTRY	NUMBER ISITA CATALOGUE (ALCIATI ET AL., 2005)	AMS DATE	SEX	ESTIMATED AGE AT DEATH
AC 1	"Il Principe"	Arene Candide 1	23,440±190 years BP Uncal. ^a	Male (Sergi et al., 1974; Paoli, 1974).	15 y.o. (Sergi et al., 1974); 14-15 y.o. (Paoli, 1974); 16.4 y.o. (Cowgill, 2008).
AC 2	II	Arene Candide 2		Male (Paoli et al., 1980).	Adult.
AC 3	Cranium I; postcranial bones found in I, III, IV	Arene Candide 3	10,065±55 BP Uncal. ^b	Male (Villotte , 2008, 2009).	Adult.
AC 4	Cranium IV; postcranial bones found in III, IV	Arene Candide 4		Male (Paoli et al., 1980; Villotte, 2008, 2009).	Adult.
AC 3 or 4	Ribs, hand and foot bones found in TIII and TIV	Non-attributed. Belonging to either TI, III, IV, XII-XIV			Adult.
AC 5	V	Arene Candide 5		Male (Paoli et al., 1980).	Adult.
AC 6	VB	Arene Candide 6	9,925±50 BP Uncal. ^b	Indeterminable (Infans).	4-5 y.o. (Paoli et al., 1980); 2.8 y.o. (Cowgill, 2008).
AC 7	VII	Arene Candide 7		Indeterminable (Infans).	Perinatal.
AC 8	VIII	Arene Candide 8	10,655±55 BP Uncal. ^b	Indeterminable (Infans).	6-7 y.o. (Paoli et al., 1980); 5.5 y.o. (Cowgill, 2008).
AC 9	IX	Arene Candide 9		Indeterminable (Infans).	Perinatal.
AC 10	X	Arene Candide 10	11,605±445 BP Uncal. ^c	Male (Paoli et al., 1980).	Adult.
AC 11	XI	Arene Candide 11		Indeterminable (Infans).	3-4 y.o. (Paoli et al., 1980); 2.4 y.o. (Cowgill, 2008).

THIS CATALOGUE	HUMAN REMAINS FROM CARDINI (1980) BURIALS ATTRIBUTED TO THE CATALOGUE ENTRY	NUMBER ISITA CATALOGUE (ALCIATI ET AL., 2005)	AMS DATE	SEX	ESTIMATED AGE AT DEATH
AC 12	Poscranium: TXII	Arene Candide 12	10,720±55 BP Uncal. b, 11510±385 BP Uncal. ^c	Male (Paoli et al., 1980; Villotte, 2008).	Adult.
AC 13	XIII and foot bones in III and IV	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Indeterminable (lack of diagnostic elements).	Young adult.
AC 14	XIV	Non-attributed. Belonging to either TI, III, IV, XII-XIV	10,735±55 BP Uncal. ^b	Indeterminable (lack of diagnostic elements).	Adult.
AC 15	XV	Arene Candide 13		Indeterminable (lack of diagnostic elements).	Early adolescent (Infans II) (Alciati et al., 2005).
AC 16	Adolescent "zona A"	Arene Candide 16	10,810±65 BP Uncal. ^d	Male (Formicola & Toscani, 2014).	12-14 y.o. (Formicola & Toscani, 2014); 15-9 y.o. (Cowgill, 2008); 16-17 y.o. (Paoli et al., 1980).
AC 17	Frontal bone "zona A"	Arene Candide 17		Male (Paoli et al., 1980).	Adult.
AC 18	Mandible "zona A"	Arene Candide 18		Indeterminable (Formicola, 1986b).	Young adult (Formicola, 1986b).
AC 19	VIA, and elements in secondary deposition probably belonging to the same adult individual	Arene Candide 14		Indeterminable (lack of diagnostic elements).	Adult.
AC 20	VIB, and elements in secondary deposition probably belonging to the same juvenile individual	Arene Candide 15	10,585±55 BP Uncal. ^b	Indeterminable (Infans, and lack of diagnostic elements).	Infans I (Alciati et al., 2005).
AC 21	Cranial fragments and maxillary "Cranio trofeo - Uomo della Pietra"	Not included		Indeterminable (fragmentary).	Late adolescent 15-20 y.o. (Alhaque & Molari, 2006).

THIS CATALOGUE	HUMAN REMAINS FROM CARDINI (1980) BURIALS ATTRIBUTED TO THE CATALOGUE ENTRY	NUMBER ISITA CATALOGUE (ALCIATI ET AL., 2005)	AMS DATE	SEX	ESTIMATED AGE AT DEATH
AC 22	Femur fragments found in V "Cranio trofeo - Uomo della Pietra"	Not included		Indeterminable (lack of diagnostic elements).	Late adolescent 15-20 y.o. (Alhaique & Molari, 2006).
AC 23	Ulna "Xq"	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Indeterminable (lack of diagnostic elements).	Adult.
AC 24	Humerus and juvenile ribs (9-10 years old) found in III and XII	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Indeterminable (Infans, and lack of diagnostic elements).	Infans II around 9-10 y.o.
AC 25	Hand bones found in XII	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Indeterminable (lack of diagnostic elements).	Adult.
AC 26	Os coxae right and left belonging to the same individual of uncertain spatial collocation	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Male.	Adult.
AC 27	Adult hand phalanx from burial V which does not belong to Arene Candide 5	Not included		Indeterminable (lack of diagnostic elements).	Adult.
AC 28	Juvenile acetabulum found on Arene Candide 1 feet area	Not included		Indeterminable (lack of diagnostic elements).	13-16 y.o. (Alhaique & Molari, 2006).
AC 29	Talus excavation 2011	Not included		Indeterminable (lack of diagnostic elements).	Young adult (size).
AC 30	Cervical vertebra (C4?) Infans I (around 4 years old) found in XII	Non-attributed. Belonging to either TI, III, IV, XII-XIV		Indeterminable (lack of diagnostic elements).	Infans I around 4 y.o.
AC 31	Adult cranial fragments found "above XV"	Not included		Indeterminable (fragmentary).	Adult.